

PTO 05-[3468]

Japanese Patent

Hei 4-81493

SOIL ENHANCER

[Dojo Kairyozaï]

Kinichi Inoue

UNITED STATES PATENT AND TRADEMARK OFFICE

Washington, D.C.

May 2005

Translated by: Schreiber Translations, Inc.

Country : Japan

Document No. : Hei 4-81493

Document Type : Kokai

Language : Japanese

Inventor : Kinichi Inoue

Applicant : Hanyo Kagaku K.K.

IPC : C 09 K 17/00, E 01 C 19/20, E 02  
D 3/12

Application Date : July 24, 1990

Publication Date : March 16, 1992

Foreign Language Title : Dojo Kairyoza

English Title : SOIL ENHANCER

## Specification

### 1. Title of the invention

SOIL ENHANCER

### 2. Claims

1. A soil enhancer, characterized by being constituted by mixing a paramagnetic substance and an aluminum group compound.

2. A soil enhancer, characterized by being constituted by mixing a paramagnetic substance, an aluminum group compound, and a calcium phosphate group compound.

### 3. Detailed explanation of the invention

(Industrial application field)

The present invention pertains to a soil enhancer being applied to soils such as tennis courts, playgrounds, and golf courses that require good drainage.

(Prior art)

In the construction of various kinds of outdoor lands such as tennis courts, playgrounds, and golf courses, it is in demand that a good drainage be always provided.

---

<sup>1</sup> Numbers in the margin indicate pagination in the foreign text.

As a conventional means for improving the drainage, a means that digs up a land, lays a gravel layer as the lower layer, lays a soil with a small amount of clay and a large amount of fine grain sands as the surface layer, and consolidates them has been mainly adopted.

Also, in Japanese Kokai Patent Application No. Sho 63[1988]-54936, an active material in which a divalent or trivalent iron salt is dispersed and carried on an alumina hydrate is presented.

(Problems to be solved by the invention)

However, in the above-mentioned means, very complicated public works were required, and for this reason, enormous expenses and days were required.

Furthermore, the active material presented in the above-mentioned Japanese Kokai Patent Application No. Sho 63[1988]-54936 was used for deodorization, antibacterial effect, and bioactivities, and it is not suggested that it can be used in applications as a soil enhancer.

The purpose of the present invention is to provide a soil enhancer that does not require very complicated public works required in the prior art in the construction of outdoor lands with good drainage and can easily obtain soils with good

drainage at low cost, simply by adding a small amount of soil enhancer to ordinary soils.

(Means to solve the problems)

/2

These inventors reviewed the above-mentioned problems in earnest to solve them, and as a result, the present invention was achieved.

In other words, the essence of a first invention of the present invention is a soil enhancer being constituted by mixing a paramagnetic substance and an aluminum group compound.

Also, the essence of a second invention is constituted by mixing a paramagnetic substance, an aluminum group compound, and a calcium phosphate group compound.

Next, the present invention is explained in detail.

First, the soil enhancer of the first invention is explained.

As the paramagnetic substance being used in the present invention, ferrite ( $M \cdot Fe_2O_3$ ) (M represents a divalent metal such as Fe, Mn, and Zn), iron oxyhydroxide (example:  $\gamma$ -FeOOH and  $\delta$ -FeOOH), maghemite ( $\gamma$ - $Fe_2O_3$ ), etc., are mentioned, and its particle diameter is preferably 100  $\mu m$  or less. The paramagnetic substance is positively charged (for example, ferrite is + 0.66 (in Xe)) and exhibits a coagulation on to

clay. Also, a so-called magnetic effect for increasing the circulation of water by a magnetism is shown.

Also, as the aluminum group compound, boehmite alumina ( $\gamma$ - $\text{Al}_2\text{O}_3$ ) is mainly mentioned, and ultra fine fibrous particles with a length of 10  $\mu\text{m}$  or less are preferable. The above-mentioned boehmite alumina forms an alumina hydrate sol. The alumina group compound is also positively charged similarly to the above-mentioned paramagnetic substance, exhibits a high coagulation action on clay, gives an alkali to prevent the change in quality of the paramagnetic substance to the above-mentioned paramagnetic substance, and has a function of preventing the aggregation by dispersing and carrying the paramagnetic substance.

The mixture ratio of the above-mentioned two components in the first invention is preferably 1-20 wt% and 80-99 wt% aluminum group compound. If the ratio of the paramagnetic substance is less than 1 wt%, the improvement effect of the soil drainage of the present invention is not sufficiently exerted, and if the ratio is more than 20 wt%, not only the above-mentioned drainage effect is not exerted, but the cost is raised, which is not preferable.

The soil enhancer of the first invention is prepared as follows, for instance. A mixed powder being obtained by drying

a coprecipitated sol of the paramagnetic substance and the aluminum group compound mixed in advance at the above-mentioned ratio is prepared, and a dilute aqueous solution (1-2%) of an inorganic binder (for example, phosphoric acid, aluminum phosphate, acidic magnesium phosphate, etc.) was added and mixed at about 2 parts by weight to the above-mentioned mixed powder at 100 parts by weight and used as a raw material. It was molded into an appropriate shape at a moisture fraction of 3% or less under pressurization (a pressure of 30-100 kg/cm<sup>2</sup>), heated at 300°C or lower for about 1 h in a heating furnace to form a cured body, and pulverized (40-400 mesh), so that a powder is obtained.

Next, the difference between the soil enhancer of the second invention and that of the first invention is mainly explained.

As the components being used in the present invention, a calcium phosphate group compound is mixed in addition to the above-mentioned paramagnetic substance and aluminum group compound. As the calcium phosphate group compound, apatite ( $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH}\cdot\text{F})_2$ ), tricalcium phosphate ( $\text{Ca}_3(\text{PO}_4)_2$ ), calcium hydrogen phosphate ( $\text{CaHPO}_4$ ), etc., are mentioned. The calcium phosphate group compound slightly dissolves  $\text{Ca}^{2+}$  of 20-200 ppm/h per 1 g, has a coagulation action on clay similarly to the

above-mentioned two components, and exhibits a cationic action in which the attraction of water molecules is increased by giving an activity to a magnetic action of the paramagnetic substance.

In the present invention, the calcium phosphate group compound itself slightly dissolve  $\text{Ca}^{2+}$ , and the compound being generated by the reaction with other components in an aqueous solution is cured in a drying process. In other words, since the bonding strength is further increased by heating at relatively low temperature up to  $300^{\circ}\text{C}$ , each component can be bonded without reducing or eliminating their functions, so that no additional binder is required to be added during the preparation.

In the second invention, the mixture ratio of each component is preferably the calcium phosphate group compound at 50-100 parts by weight to two components (paramagnetic substance + aluminum group compound) at 100 parts by weight constituted by the above-mentioned mixture ratio in the first invention. If  $\frac{1}{3}$  the mixture ratio of the calcium phosphate group compound is deviated from the above-mentioned range, the improvement effect of the soil drainage of the present invention is not sufficiently exerted, which is not preferable.



The soil enhancer of the second invention is prepared as follows, for instance. A slurry (composed of an aqueous phosphoric acid solution of 5-20 wt% fine powder of the calcium phosphate group compound with a mesh of 200 or less and 2% or less the balance) of the calcium phosphate group compound is added and mixed with a mixed powder of the paramagnetic substance and the aluminum group compound, so that a raw material is obtained. It is molded under pressurization by a method similar to the above-mentioned method, heated, and pulverized, so that a powder is obtained.

In addition to that, a method that obtains the soil enhancer by mixing a mixed sol due to the coprecipitation of basic aluminum salt (aluminum chloride, aluminum sulfate, aluminum nitrate, etc.) and an iron salt solution with the calcium phosphate group compound is also adopted.

The soil to which the soil enhancer of the present invention is not particularly limited, and any soils may be adopted. Hard soils in which the dry density is high and the drainage has been poor can further exert the effects of the present invention.

Also, as a method that adds the soil enhancer of the present invention to soils, a method that mixes the soil enhancer and soils, a method that sprays the soil enhancer on

soils, etc., are mentioned. Even in the latter method by spraying only, the drainage effect of the present invention is sufficiently exerted, and efforts can also be further saved. Thus, it can be said as a more preferable method.

Furthermore, the addition ratio of the soil enhancer of the present invention to soils is not particularly limited, and the ratio is preferably about 0.5-1 part by weight to the soils at 100 parts by weight. If the ratio is less than 0.5 part by weight, the drainage effect of the present invention is not sufficiently exerted in some cases, and even if the amount being added exceeds 1 part by weight, the drainage effect reaches its limit, so that the cost is wastefully spent.

(Operation)

In the first invention, the amount of water being circulated in soils to which the soil enhancer is added is increased by the magnetism of the paramagnetic substance. Also, the above-mentioned paramagnetic substance and the aluminum group compound are positively charged, and they exhibit a coagulation action on an aggregator of clay particle hydrate spheres in the soils in which a thick water film is formed. In other words, the negative charges of the clay particles being negatively charged are neutralized, and the attraction of water molecules due to the hydrogen bond between the clay particles is

considerably reduced, so that the water flowability is improved. Furthermore, the aluminum group compound gives an alkali for preventing the change in quality to the paramagnetic substance and prevents the aggregation by dispersing and carrying the paramagnetic substance.

Also, in the second invention, in addition to the above-mentioned two components, with the addition of the calcium phosphate group compound, the above-mentioned coagulation action is further increased. Also, the compound being generated by an aqueous solution reaction exhibits a curing action in a drying process, and the bonding strength with the other two components is increased.

(Application examples)

Next, the present invention is explained in further detail by application examples and comparative examples.

As the soil, the following two kinds of soils were prepared.

Soil I for a raw material (Kison sand for Metsuchi): about 15% clay, about 79% sand (particle diameter: 47% smaller than 0.5  $\mu\text{m}$ , 45.5% 0.5  $\mu\text{m}$  or greater and smaller than 1.0  $\mu\text{m}$ , and 7.5% 1.0  $\mu\text{m}$  or greater), about 6% water

Soil II for a raw material: about 18% clay, about 76% sand (particle diameter: 46% smaller than 0.5  $\mu\text{m}$ , 48.3% 0.5  $\mu\text{m}$  or

greater and smaller than  $1.0\ \mu\text{m}$  , and 5.7%  $1.0\ \mu\text{m}$  or greater), about 6% water

As the soil enhancer, the following two kinds were prepared.

Sample A (two components): 10% maghemite ( $\gamma\text{-Fe}_2\text{O}_3$ ), 89% boehmite ( $\gamma\text{-Al}_2\text{O}_3$ ), and 1% binder (aluminum phosphate)

(Working method) The above-mentioned composition was pressurized at a pressure of  $30\text{-}50\ \text{kg}/\text{cm}^2$  in a state of 2.5% moisture, and a small segment of  $1\ \text{cm}\varnothing$  was formed, baked at  $300^\circ\text{C}$  for 1 h, and pulverized to a powder with a mesh of 80 or less.

Sample B (three components): 5% ferrite ( $\text{Fe}_3\text{O}_4$ ), 45% boehmite, and 50% tricalcium phosphate ( $\text{Ca}_3(\text{PO}_4)$ )

(Working method) A slurry of a phosphoric acid solution (concentration: 2%) containing 20% tricalcium phosphate (200 /4 mesh or less) as a solid fraction was prepared in advance.

The slurry was added to a powder of the ferrite and the boehmite, mixed, and dried so that the above-mentioned composition might be attained based on a solid fraction. Then, it was dried, baked, and pulverized in a state of 2.5% moisture by the same method as that of the sample A, so that a powder with a mesh of 80 or less was formed.

Sample soil: The above-mentioned soil I or II for a raw material at 100 parts by weight was mixed with the above-

mentioned sample A or B at 0.1 part by weight, so that a treatment section soil was attained. On the other hand, for comparison, a soil to which the samples were not added was formed as an untreated section soil.

Next, using an apparatus according to JIS A-1218, a sampler (100 cc) for water permeation was installed at the bottom of a mold, and the sample soil was filled into it and consolidated 25 times by a stamp, so that four kinds of samples with a different dry density (showing the degree of consolidation) were prepared.

Each sample prepared was saturated with water for 24 h, and the water permeability coefficient was measured by a constant water level method.

The results obtained are shown in Tables I-III.

However, water permeability coefficient  $K = U_T \cdot L \cdot Q / U_{15} \cdot h \cdot A \cdot t$  (A: 19.6 cm<sup>2</sup> sample cross section, L: 5.0 cm sample length, h: 7.0 cm water level difference, t: measurement time (h), Q: amount of water permeated (cc), and  $U_T$ : viscosity coefficient of water at T°C)

Also, the unit of the dry density in Tables I-III was g/cm<sup>3</sup>, and the water permeability coefficient value was a value calculated by mm/h as a unit.

Table I

No.	実 施 例			
	土 壌	試 料	乾 燥 密 度	透 水 係 数
1	I	A	1. 3 0	1 6 9. 2
2	"	"	1. 3 6	1 5 2. 2
3	"	"	1. 4 1	1 3 4. 1
4	"	"	1. 5 0	1 1 3. 9
5	"	B	1. 3 0	1 7 2. 2
6	"	"	1. 3 9	1 5 8. 1
7	"	"	1. 4 5	1 3 8. 5
8	"	"	1. 5 0	1 2 0. 2

1. Application Example
2. Soil
3. Sample
4. Dry density
5. Water permeability coefficient

Table II

實 施 例				
No.	土 壤	試 料	乾 燥 密 度	透 水 係 數
9	II	A	1.32	160.3
10	"	"	1.37	149.4
11	"	"	1.46	131.1
12	"	"	1.51	110.4
13	"	B	1.30	169.5
14	"	"	1.38	150.6
15	"	"	1.45	136.8
16	"	"	1.51	122.5

1. Application Example
2. Soil
3. Sample
4. Dry density
5. Water permeability coefficient

Table III

/5

No	比較例			
	土壤	試料	乾燥密度	透水係数
1	I	—	1.30	150.5
2	"	—	1.38	139.7
3	"	—	1.45	72.5
4	"	—	1.50	48.9
5	"	—	1.31	148.2
6	"	—	1.38	132.3
7	"	—	1.45	70.8
8	"	—	1.51	47.1

1. Comparative Example
2. Soil
3. Sample
4. Dry density
5. Water permeability coefficient

As seen from Table I, it is understood that the soils mixed with the soil enhancer of the present invention, the drainage is improved in both the soils I and II (comparison of Application Examples 1-4 and Comparative Examples 1-4, comparison of Application Examples 4-8 and Comparative Examples 1-4, comparison of Application Examples 9-12 and Comparative Examples



5-8, and comparison of Application Examples 13-16 and Comparative Examples 15[sic; 5]-8).

Also, it is understood that an excellent effect was exerted for the soils with a high dry density, that is, the hard soils in which the drainage has been poor and the drainage was improved about twice or more for the hardness of the dry density of 1.4 or more (comparison of Application Examples 3 and 4 and Comparative Examples 3 and 4, comparison of Application Examples 7 and 8 and Comparative Examples 3 and 4, comparison of Application Examples 4 and 12 and Comparative Examples 7 and 8, and comparison of Application Examples 15 and 16 and Comparative Examples 7 and 8).

Furthermore, it is understood that in the soil mixed with the sample B (three components), the drainage is more improved, compared with the soil mixed with the sample A (two components) (comparison of Application Examples 1-4 and Application Examples 5-8 and comparison of Application Examples 9-12 and Application Examples 13-16).

Also, in the soil enhancer of the present invention, since each component is strongly bonded with each other and slightly soluble, the drainage is held over a long term, and any of the components is harmless to man and beast and does not contaminate environments.

(Effects of the invention)

According to the soil enhancer of the first invention of the present invention, a soil with good drainage is easily obtained at low cost simply by adding a small amount to a soil, and conventional complicated public works are not required at all.

Also, according to the soil enhancer of the second invention, the drainage is especially better among the effects of the above-mentioned first invention.